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OPTIMIZATION OF DIESEL ENGINE PARAMETERS WITH BLEND OF PONGAMIA BIODIESEL AND DIESEL USING TAGUCHI METHOD

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ABSTRACT

Biodiesel is an alternative to conventional diesel fuel made from renewable resources, such as non-edible vegetable oils. The oil from seeds (Ex. Jatropa, Neem, Pongamia, etc,) can be converted to a fuel commonly referred to as "Biodiesel." No engine modifications are required to use biodiesel in place of petroleum based diesel. Biodiesel can be mixed with petroleum-based diesel in any proportion. This interest is based on a number of properties of biodiesel including the fact that it is produced from a renewable domestic source, its biodegradability, and its potential to reduce exhaust emissions.

In this project work, optimization of diesel engine parameters is carried out experimentally. The biodiesel used is Pongamia and its blends with diesel, injection opening pressure, number of nozzle holes, and compression ratio is varied to study the effects on diesel engine performance. Brake thermal efficiency is optimized using Taguchi methodology to analyze the experimental data. The optimum operating parameters which gives maximum brake thermal efficiency is B80, injection opening pressure 200 bar, 3 hole nozzle and 18 compression ratio. The confirmatory test has been made and the brake thermal efficiency is obtained matches with the theoretical calculation using Taguchi optimal method.

KEYWORDS: Bio-Diesel, Pongamia, Taguchi Method, Response Curves, Operating Pressure, Nozzle Holes, Compression Ratio, Brake Thermal Efficiency

INTRODUCTION

Biodiesels and its blends with diesel can be used on diesel engines without any engine modifications. It also shows that, engine performance changes with engine parameters like compression ratio, injection opening pressure, number of nozzle holes and different blends of biodiesel and diesel. Researchers are making a sincere attempt to find out the suitable alternative to diesel fuel which does not require major engine modifications. The review of literature is carried out on that basis. A brief discussion of some important research findings presented below. Figure 1 shows pongamia plant.

Maulik A Modi, et al. [1] conducted an experiment to study palm seed oil blended with diesel used in a single cylinder diesel engine. Palm Seed oil is obtained from the seeds of the palm tree. In this study, the effects of parameters i.e. load, compression ratio and injection pressure are taken as variable for optimization. As the experiment required simultaneously optimization of three parameters with three levels, they studied Taguchi method optimization in this experiment. The results of the Taguchi experiment identify that 16 compression ratio, injection pressure 180 bars and engine load 10kg are optimum parameter setting for highest brake thermal efficiency.

Figure 1: (a) Healthy PongamiaPinnata Plant (b) Leaf (c) Flower (d) Pods (e) Seeds (f) Roots (g) Bark

Krunal B Patel, et al. [2] wascarried out an experiment to study pyrolysis oil blended with diesel used in single cylinder diesel engine. Pyrolysis oil is obtained from the tire waste by pyrolysis process. Blending of pyrolysis in maximum possible proportion helps to reduce the consumption of diesel fuel.

Vincent H. Wilson, Udaykumar [3] conducted an experiment for optimization of control parameters of the direct injection (DI) single cylinder diesel engine with respect to the NO_X (Oxides of Nitrogen) and fuel emissions through experimental investigations and taguchi method. In this experiment a single cylinder 5.2 kW diesel engine was selected for this experiment. They studied five parameters such as clearance volume, valve opening pressure nozzle-hole diameters, static injection timing, load torque were varied at four levels and the responses such as NO_X emissions and fuel economy were recorded.

Nimesh G Gandhi, Hardik M. Patel [4] studied injection pressure of four stroke four cylinder diesel engine for low emissions using Taughi method. To optimize injection pressure of diesel engine from 100 to 250 bar with the increment of 50 bar by shim adjusting inside the atomizer for increasing engine performance values such as power, torque and specific fuel consumption have been measured and minimize emission of engine using Taguchi method. According to the results by optimizing injection pressure, the maximum performance has been obtained at 150 bar pressure and 2500 rpm engine speed. In addition, high injection pressure for O_2 and CO_2 low injection pressure for NO_X and smoke levels

must be preferred for decreasing emissions. From the study the optimal setting of the injection pressure is determined.

GorkemKokkulunk et al. [5] optimal engine performance and pollutant emission conditions are investigated by using Taguchi Design Methods. Orthogonal arrays of Taguchi, the signal-to-noise (S/N) ratio and the analysis of variance (ANOVA) were employed to find the optimal levels and to analyze the effect of the operation conditions on performance and emission values. The parameters and their levels are engine speeds at 1200, 1600, 2000 and 2400 rpm, steam ratios of 0, 10, 20 and 30% and EGR ratios of 0, 10, 20 and 30%. Confirmation tests with the optimal levels of engine parameters were carried out in order to illustrate the effectiveness of the Taguchi optimization method.

Mr. K .H. Siju Dr. P. P. Rathod et al. [6] carried out an experiment to investigate the combine effect of EGR and Injection Pressure for the performance of Direct ignition CI engine by using Karanja Biodiesel. To reduce number of experiments, Taguchi method of DOE has been used. Optimum parameters from Taguchi method were validated by experiments and compared the results. The optimum sets were found for BSFC and BTE at 10% Blend, 0% EGR, 180 bar Injection Pressure and 12 kg Load.

K. PrasadaRao, et al. [7] conducted an experiment to study the optimization of performance parameters to improve diesel engine efficiency. An attempt has been made to solve the correlated multiple criteria optimization problem of performance parameters of diesel engine. The process environment has been assumed consisting of four variables load, time taken for 10cc fuel consumption, type of fuel, valve opening position. Taguchi method has been adopted to convert multiple objectives of the optimization problem into a single objective function. Taguchi's technique has been applied to determine the optimal setting, which can maximize the output parameters Break thermal Efficiency,co_2%,and can minimize F.C.H,B.S.F.C, CO%,HC,O_2%.The result of this optimization technique has been imported to that of Grey-Taguchi technique, another approach which is widely used for solving multi criteria optimization problems. A confirmatory test showed satisfactory result by artificial neural network in MATLAB.

Shivaram krishanKalimoorthy, Ravikumar Parmasivam, [8] studied an experiment to investigate the effects of engine parameters on the performance and the emissions characteristics of a single cylinder 5.2 kw diesel engine. The experiments were designed using a statistical tool known as design of experiments based on Taguchi. Five parameters, namely, power, static injection pressure, injection timing, fuel fraction, and compression ratio were varied at four levels and the responses brake power, fuel economy and emissions were investigated.

Sylvio C.A.de Almeida et al [9] investigated performance of a naturally aspirated MWM 229 direct injection four-stroke 70 kW diesel-generator fuelled with 100% palm oil. During investigation the palm oil is heated to 100°C for improving the fuel properties like viscosity for better combustion and lower engine deposits. They observed inferior engine performance due to its higher viscosity and they also observed clogging of fuel lines and starting difficulties in low temperatures.

T. VenkateswaraRao et al.[10] conducted experimental investigation on performance and emission characteristics of diesel engine fuelled with methyl esters of pongamia (PME), Jatropha (JME) and Neem (NME) oil and its blends with diesel. During investigation, they observed that engine performance and emissions with B20 (20% PME and 80% diesel) were closer to diesel.

EXPERIMENTAL SETUP AND METHODOLOGY

The engine used is a single cylinder, four stroke, DI, water cooled, computerized Kirloskar make diesel engine. Figure 2 shows line diagram and the experimental setup.

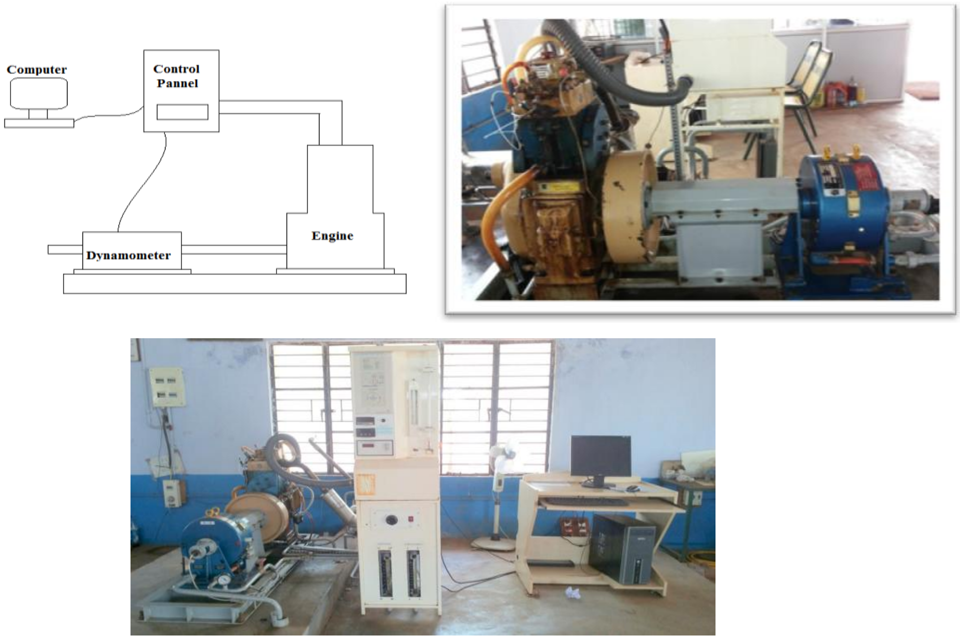

Figure 2: Experimental Setup

An eddy current dynamometer is attached to the engine for loading. Various sensors for measurement of cylinder pressure, fuel line pressure, exhaust gas temperature, fuel consumption, air consumption, crank angle and speed, etc. are attached to the engine at appropriate position. Signals from sensors are amplified, conditioned and used for evaluating various engine performance and combustion characteristics. A powder coated panel box with two fuel tanks, a fuel measuring burette, an air box with a mercury manometer, a dynamometer controller with display unit, etc. is attached to the engine.

RESULTS AND DISCUSSIONS

Experimental Data Using Taguchi Method; Analysis for Response Curve

Response curve analysis is aimed at determining influential parameters and their optimum levels. It is a graphical representation of change in performance characteristics with the variation in process parameter. The curve gives a pictorial view of variation of each factor and describes what the effect on the system performance would be when a parameter shifts from one level to another. Figure 3 & 4 shows Main Effects Plot for Brake Thermal Efficiency.

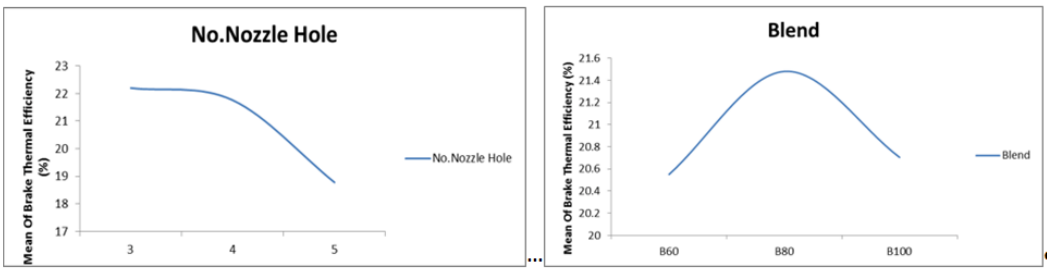

Figure 3: Number of Nozzle Holes v/s Mean of Brake Thermal Efficiency; Blend v/s Mean of Brake Thermal Efficiency

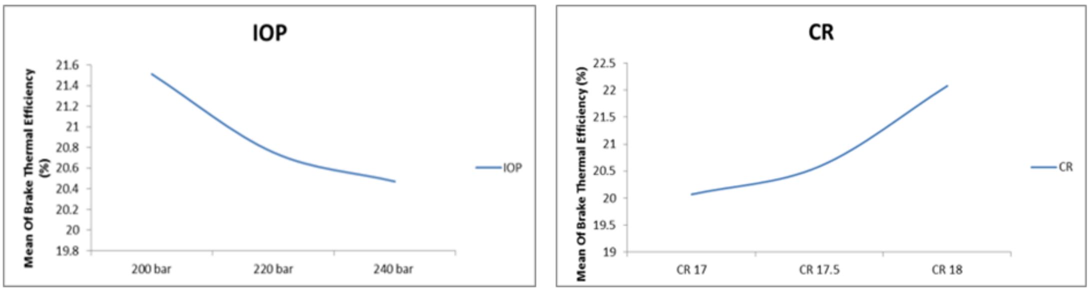

Figure 4: Injection Opening Pressure v/s Mean of Brake Thermal Efficiency; Compression Ratio v/s Mean of BTE

From the graphs, the mean value is maximum (22.20%) for 3 nozzle holes & minimum (18.77%) for 5 nozzle holes. The mean value is maximum (21.481%) for B80 biodiesel blend and minimum (20.551%) for B60 biodiesel blend. The mean value is maximum (21.513%) for 200 bar injection opening pressure and minimum (20.471%) for 240 bar injection opening pressure. The mean value is maximum (22.08%) for 18 compression ratio and minimum (20.07%) for 17 compression ratio.

The S/N Ratio for the performance curve were calculated at each factor level and average effects were determined by taking the total of each factor level and dividing by the number of data points in the total. The greater difference between levels, the parametric level having the highest S/N ratio corresponds to the parameters setting indicates highest performance.

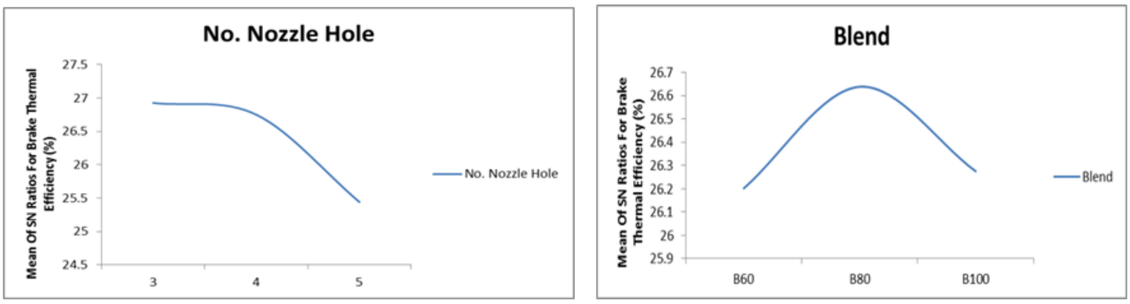

Figure 5: Number of Nozzle Hole V/S Mean of S/N Ratio for BTE; Blend V/S Mean of S/N Ratio for BTE

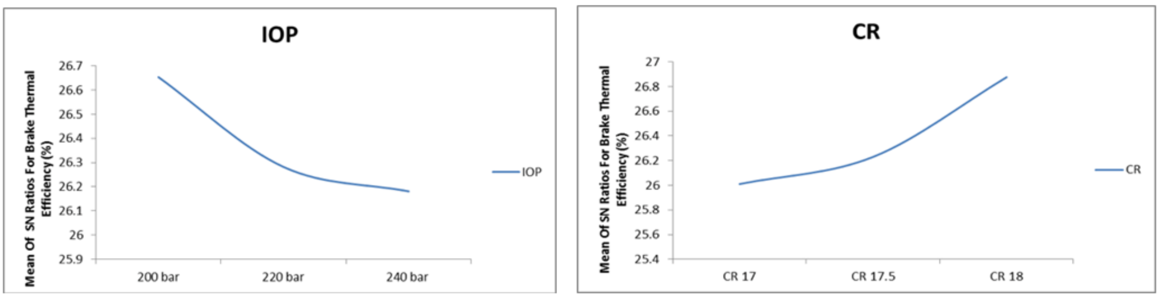

Figure 6: Injection Opening Pressure V/S Mean of S/N Ratio for BTE; Compression Ratios V/S Mean of S/N Ratio for BTE

From figures 7 & 8, the response curve for S/N ratio, the highest was observed at 3 nozzle holes (26.92605), biodiesel blend B80 (26.63835), injection opening pressure 200 bar (26.6534) and 18 compression ratio (26.87577), which are optimum parameter setting for highest brake thermal efficiency.

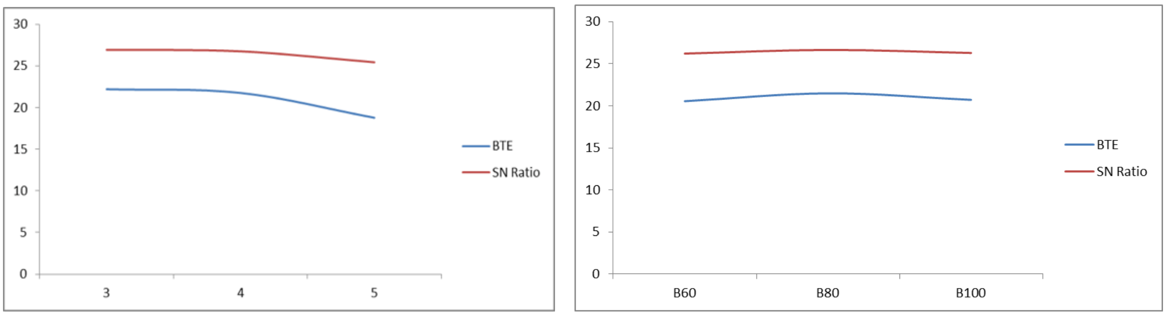

Figure 7: Common Graph for BTE & SN Ratio for Number of Nozzle Holes Common Graph for BTE & SN Ratio for Blend

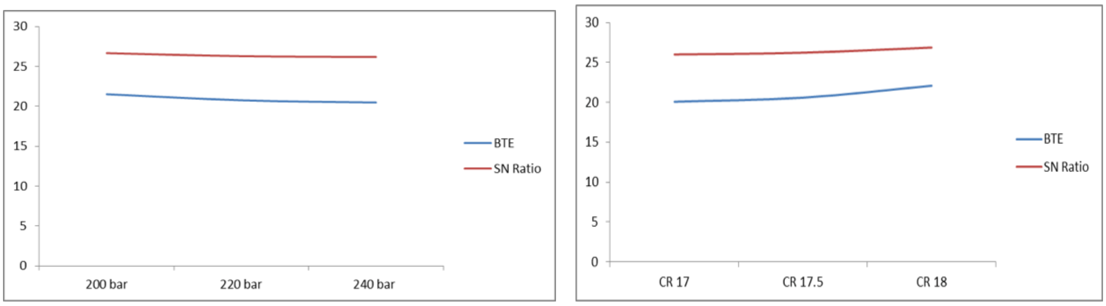

Figure 8: Common Graph for BTE & SN Ratio for Injection Opening Pressure Common Graph for BTE & SN Ratio for Compression Ratio

From figures 9 & 10, the common graph which is drawn for mean of Brake Thermal Efficiency and Mean of SN Ratios for Brake Thermal Efficiency. Graphs show that the optimum value is 3 nozzle holes, B80 Biodiesel, 200 bar Injection Opening Pressure, 18 compression ratio, for both Mean of Brake Thermal Efficiency and Mean of SN Ratio for Brake Thermal Efficiency.

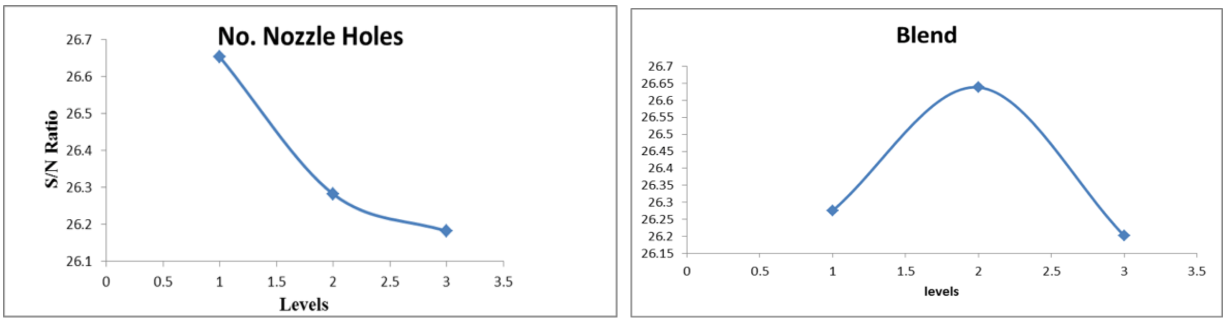

Figure 9: Levels v/s Mean S/N Ratio for No. of Nozzle Holes and Levels v/s Mean S/N Ratio for Pongamia Biodiesel and its Blends with Diesel

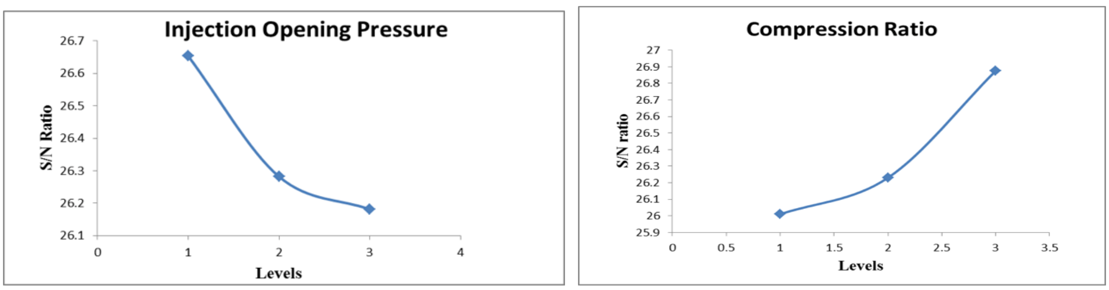

Figure 10: Levels v/s Mean S/N Ratio for Injection Opening Pressure (IOP) Levels v/s Mean S/N Ratio for Compression Ratio

For the engine performance, the response variable BTE was higher the better. The criteria for optimization of the response parameters was based on the Higher-the better S/N ratio. The experimental results were substituted in equation to calculate the S/N ratios for all response variables and they are shown in Figure 8 and 9. From the value, the optimization the engine parameters were obtained shown in table 1.

Table 1: Optimum Combination of Parameters for Response Variable (BTE)

Parameters	Optimal Level
No. of nozzle holes	3
Biodiesel blend	B80
Injector opening pressure (IOP)	200bar
Compression ratio	18

Confirmatory Test

After selecting the optimal levels of the controlling parameters, the final step is to verify the results using the optimum design parameter levels in comparison with standard engine parameters with biodiesel fuel. A confirmation test for the combined objective is conducted by choosing the five design and control parameter are found in multi objective optimization.

The confirmation test was conducted with optimized parameters given in table 2.

Table 2: Comparison of Predicted Value and Confirmation Test Value for Optimum Parameters Combination

Response Variable	Predicted Value at Optimum Condition Using Taguchi's Method	Confirmation Test Value at Optimum Condition
Brake Thermal Efficiency (%)	24.53667	24.12

CONCLUSIONS

From this study it is seen that biodiesel is going to be the natural choice for our future transport fuel, agricultural and industrial purpose.

From the above study the response parameter i.e., Brake Thermal Efficiency is optimized using Taguchi's methodology to analyse the experimental data. The main effects plot for signal to noise ratio the optimized combination is found to be No. of nozzle hole=3, Blends B80, I.O.P =240 and C.R=17. In this particular combination it is predicted from the experimental data that the engine performance is comparable to that of diesel. That means from the used blends of biodiesel and diesel, the B80 blend is found to be most suitable blend for use in the diesel engine without any engine modification. The corresponding compression ratio is 18 and the load applied on the engine is 100% load, i.e.12kW load. The confirmation test is also carried out to verify it and there we see improvements of signal to noise ratio.

And finally it can be concluded that the biodiesel can be used in a diesel engine without any engine modifications. And from our experimental view, the best blend is the B80 blend where the engine performance is comparable to that of diesel.

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